STRAWBERRY CULTURE

SOUTH ATLANTIC and GULF COAST REGIONS

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U. S. DEPARTMENT OF AGRICULTURE

STRAWBERRY growing is an important industry in certain districts of the South Atlantic and Gulf Coast States.

Because of the mild climate, especially in the warmer parts, the plants grow during nearly the entire year.

Methods of culture and handling are quite different in many respects from those in other parts of the country; those which have proved successful are described and their significance indicated in this bulletin.

The commercial importance of one strawberry-growing district compared with other districts is determined largely by the ripening period of the crop. Fruit from the South Atlantic and Gulf coast regions is usually marketed when there is little or no competition.

Important strawberry-growing districts in the territory covered by this bulletin do not, as a rule, compete seriously with one another in the marketing of the crop.

Shipments of strawberries begin from central Florida early in the winter and continue in succession from the various districts northward until the fruit ripens in the northern districts.

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STRAWBERRY CULTURE: SOUTH ATLANTIC AND GULF COAST REGIONS

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Contents

AREA TO WHICH THIS BULLETIN APPLIES

THE area to which this bulletin applies is shown in figure 1. It includes in general the coastal plain of Texas, Louisiana, Mississippi, Alabama, Georgia, Florida, South Carolina, and North Carolina. This is the part of the United States where fruit buds are usually formed in the fall, during the winter, and in the spring in contrast to sections farther north, where they are formed only in the fall.

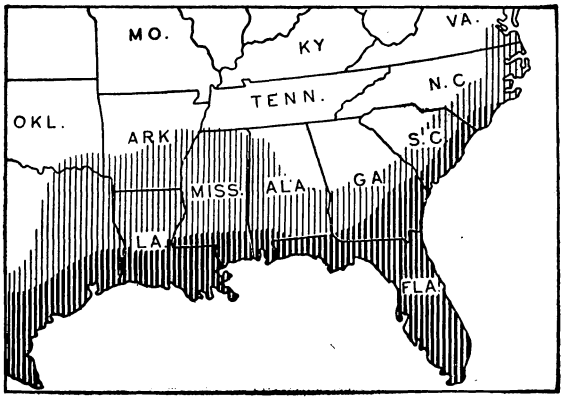

FIGURE 1.—The area to which this bulletin applies in the South Atlantic and Gulf Coast States is indicated by shading. Heavy shading shows the sections where the hill system of strawberry culture is commonly practiced and light shading the sections where matted and spaced rows are used.

Strawberries are shipped to northern markets from different districts in this area throughout the winter and early spring. The shipments totaled about 7,900 carloads in 1937 and 6,800 carloads in 1938, or about two-thirds of the total shipments of the country. The map in figure 2 shows the large centers of strawberry production in the South, as well as in other sections of the country, and the approximate season of ripening in each.

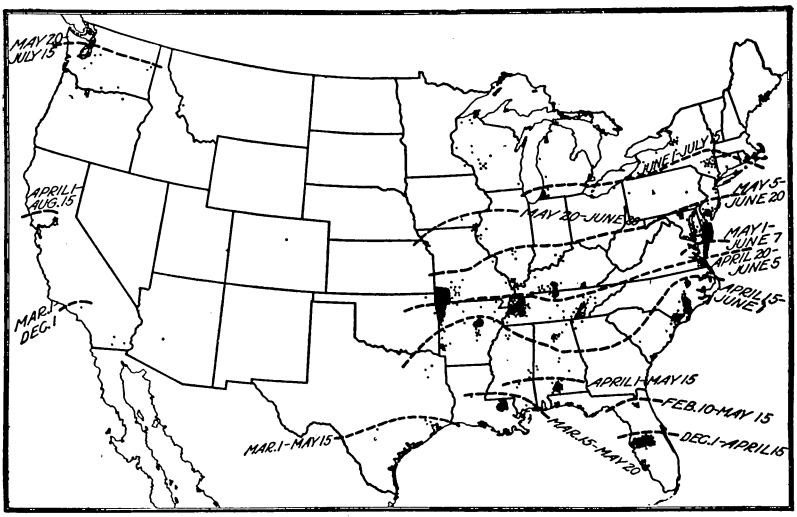

FIGURE 2.—Outline map of the United States, showing the approximate shipping season for each section. Dots show specific locations of the more important shipping districts.

Strawberry-growing practices in parts of the South are very different from those used in the Northern States, and for that reason directions applicable to strawberry growing in other parts of the country are of small value there.[1]

LOCATING THE PLANTATION

Factors that determine a favorable location for strawberry raising include: Facilities for shipping the fruit; convenience in obtaining pickers and crates, boxes, and other supplies; and the ripening time of the fruit in relation to its ripening time in other strawberry-growing districts. A location in which the berries ripen at a period when markets are not well supplied with them is better, other things being equal, than one in which the fruit ripens when it must meet competition from the berries of other districts. It is usually easier to obtain transportation, supplies, and experienced help where strawberries are already being grown and shipped in quantities than in localities where strawberry growing is not a community interest.

The map in figure 2 shows that the strawberry-ripening season moves northward during the winter and spring, and shipping from each district ends when berries in the district next north are ripe,

[1] See Farmers' Bulletins 1027, Strawberry Culture: Western United States; 1028, Strawberry Culture: Eastern United States; and 1043, Strawberry Varieties in the United States.

unless a poor crop in some district provides growers south of that district with a profitable shipping season longer than usual. By noting the districts in which berries ripen at the same time and the railroad lines or highways over which they are shipped the logical market for berries from any given district can readily be determined.

Shipping seasons along the Atlantic coast succeed each other about as follows: The Plant City district in Florida is normally the only source of strawberries for northern markets in December and January, and shipments from that district usually are at their height in February, when the Starke-Lawtey district in north-central Florida begins to ship small quantities. In March shipments from the latter district become heavy and those from the Plant City district become lighter, unless late frosts or other weather conditions retard ripening in northern localities and favor those farther south.

In the latter part of April shipments from North Carolina become heavy and those from northern Florida are discontinued. Then berries from the Norfolk district replace those from North Carolina, and are later superseded by shipments from districts still farther north. Similar crop successions occur in Alabama, Louisiana, Mississippi, Texas, and other States up the Mississippi Valley.

SOIL

No particular type of soil is best adapted to the varieties of strawberries grown in a given area. In Texas, coarse sandy, fine sandy, and heavy gumbo soils are used extensively; in Louisiana, a heavy silt loam and sandy loam; in Florida, both heavy silt and coarse sandy loams and muck soils; and elsewhere still other soil types. In each section the soil type most easily managed and having the greatest content of humus (decaying vegetable matter) is generally preferred. In the vicinity of Houston, Tex., a gumbo soil mixed with a large quantity of sand is favored; in the section about Hammond, La., a silt loam mixed with sand; and in the Plant City district in Florida, a black sandy soil.

DRAINAGE

The strawberry is easily injured by poor soil drainage and requires soils on which water never stands. In the area to which this bulletin applies, this is especially important, for the land is usually low and often poorly drained. In winter the evaporation is less than at other seasons, and when heavy rains occur, the plants may be drowned out entirely or so weakened that their growth is stunted. Leaf, root, and fruit diseases will also be more abundant on such sites than where the drainage is good. Nemas (nematodes), very minute, wormlike organisms that cause the dwarf disease, may be washed from plants on high lands to those in low areas where the water stands.

PREPARATION

Land should be thoroughly prepared for growing strawberries. It should contain abundant supplies of humus when the plants are set. The humus may be supplied either by applying adequate quantities of manure, or by growing and turning under one or more green-manure crops before the plants are set. A legume such as crotalaria,

clover, soybeans, cowpeas, or some other crop adapted to the region is preferable.

WHITE GRUB

Preparation of the soil may be begun one or two seasons before the strawberry plants are set. Two seasons are required for sod land, particularly where white grubs are numerous. These grubs are the larvae of May beetles or June bugs, and are frequently abundant in sod land, where the eggs are usually laid. Because the beetles avoid fields with clover or other leguminous crops, such land can be prepared and planted at once to strawberries. If strawberries are planted on land heavily infested with white grubs, the grubs will eat the roots of the plants and cause much loss. Because the grubs remain in the soil in the larval stage for about 2 years, and because grass roots in the sod might interfere with proper preparation of the soil, hoed crops should usually be grown on such land for 2 seasons after it is plowed, before strawberries are planted in it.

BUD WEEVIL

The bud weevil, a major strawberry pest in the Southern States, overwinters under the debris in a strawberry field, under the grass, weeds, and leaves along roadsides, fence rows, ditchbanks, and the borders of strawberry fields, or in adjacent woodland or brush. In the early spring the weevil moves into the strawberry field, lays its eggs in the unopened buds, and cuts the stem just below the bud. Nearly every year this weevil destroys a large part of the crop in sections of this area. Growers who have their strawberry fields in the center of a large cultivated area, which has no borders with places for the weevils to hibernate, have had no injury whatever. Where weevil injury is serious, growers should so plan their rotations and crops that the strawberry fields are surrounded by cultivated crops, the borders are kept free from weeds and debris, and there are no woodlands within 200 yards.

INJURY BY NEMAS

Directly connected with selection of a site and preparation of the soil for a strawberry plantation is the problem of the serious damage done to strawberries in the South by nemas. One nema trouble is commonly called root knot because of its effect on the roots of the plant; another is called summer dwarf because of its effect on the plant.

Root Knot

The nema causing root knot is also called the gall nema or the eelworm. It is one-sixtieth to one-twentieth of an inch in length. It penetrates the small roots of plants and causes numerous swellings or knotlike enlargements which interfere with the passage of water through the roots (fig. 3). The roots may be affected seriously, however, even when no prominent enlargements can be seen. Gall nemas are most abundant in the South, where the soil rarely or never freezes to any considerable depth. They are more injurious in sandy than in heavy soils.

DWARF

In Florida and in some other sections one of the most serious diseases is called "dwarf," "crimps," "crimp plants," or "white buds." It is caused by a nema that lives in the crowns, buds, and

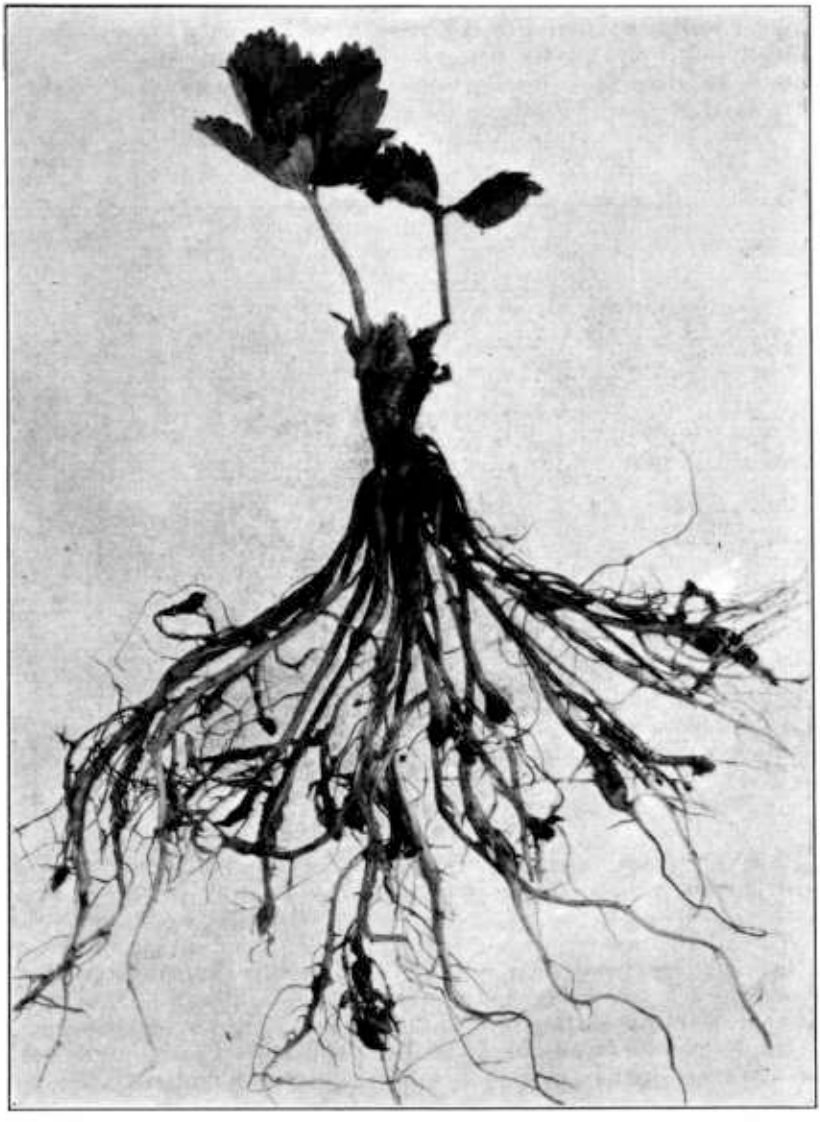

FIGURE 3.—Roots of a strawberry plant showing galls caused by the root-gall nema

leaf axils. Plants affected by it bear little or no fruit. Often no blossoms or berries are produced, though in some such cases a few imperfect berries are formed. Affected plants are recognized by a peculiar twisting and dwarfing of the central and younger leaves (fig. 4), often accompanied by a gloss and darker green of the

diseased leaves. No central bud develops in these plants, as it does in healthy plants. These symptoms appear during the period from July to September, but, except in central Florida, disappear during the winter and spring. Experienced growers are able to recognize the dwarf or crimp plants in the propagating beds and discard them. Because runners from affected plants are usually diseased, plants raised from them should be discarded. As the only known means of control is prevention by using healthy plants, all suspected plants should be discarded during setting. This disease is common in Florida, Louisiana, southern Mississippi, and North Carolina, and has been found in the Norfolk (Va.), Arkansas, and Tennessee districts.

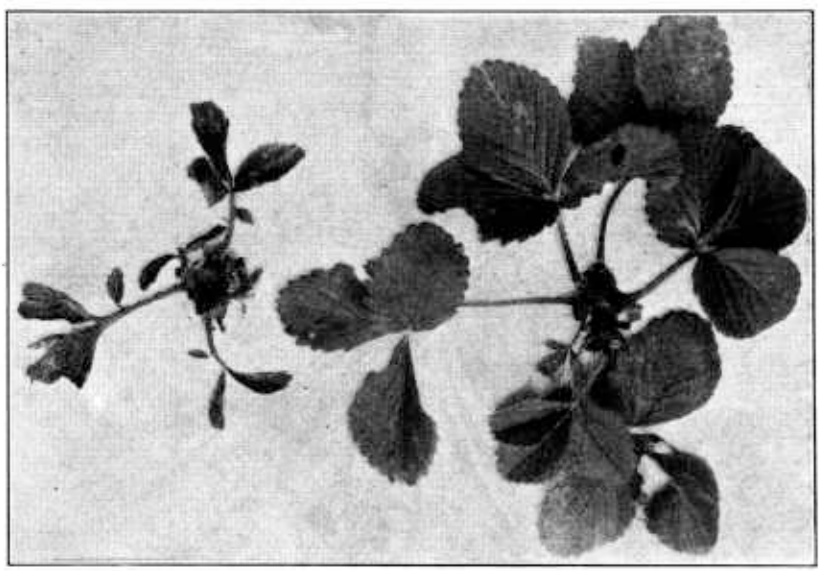

FIGURE 4.—Left, plant affected with "dwarf"; right, healthy plant

ROTATIONS

In North Carolina many growers use the following rotation: After strawberries, a nema-resistant variety of soybean or cowpea is drilled in rows; after this is turned under or harvested, winter oats are sown. In the spring the oats are plowed under or harvested, and soybeans or cowpeas planted again. After this crop is harvested or plowed under, strawberries are planted in the autumn.

Other rotations using root-knot resistant crops will be suggested by the particular needs of individual growers. Corn should not be used in the rotation, as root lice, usually very abundant after corn, do much injury to the strawberries even when the berries are planted two years after the corn. Strawberries succeed well after sweet-potatoes, but in some sections may suffer from Rhizoctonia root rot after potatoes, tomatoes, garden beans, or beets.

Whatever the crop or treatment of the soil before strawberries are planted, the soil should be so managed as to be in a high state of fertility and contain an abundant supply of humus at the time the

from July to October but, except in Florida, disappear during the winter and spring. Experienced growers are able to recognize the dwarf or crimp plants in the propagating beds and discard them. Because runners from affected plants are usually diseased, plants raised from them should be discarded. As the only known means of control is prevention by using healthy plants, all suspected plants should be discarded during setting. This disease is common in Florida, Louisiana, southern Mississippi, and North Carolina, and has been found in the Norfolk (Va.), Arkansas, Tennessee, and eastern Maryland districts. It is best to avoid planting on infested soil for at least 2 years.

ROTATIONS

With many crops rotation has been practiced because any one crop grown year after year tends to exhaust the fertility of the soil, taking out more of the available supply of one than of other fertilizer elements. With the strawberry this may be one reason for rotation, but more likely insect, disease, or weed populations have been built up in the strawberry field until some other crop must be grown. The most widely known factor affecting rotation is the white grub previously discussed. Strawberry root aphids are serious on sandy soils in most of the areas covered by this bulletin. In most years growers lose hundreds of acres of strawberries because of this pest. The losses are much greater when the strawberry follows corn, weeds, or grass, for the ants that carry the aphids from plant to plant are usually abundant following such crops. The control of the root knot nema has been discussed previously.

Because the different crops grow best on soils of different acidity, those crops succeeding best in soils of about the same acidity as the strawberry should be selected for the rotation. Field crops such as sweetpotatoes, potatoes, rye, oats, wheat, buckwheat, millet, peanuts, cowpeas, hairy vetch, crimson clover, corn, cotton, and soybeans, and garden crops such as watermelons, beans, tomatoes, carrots, cabbage, and cauliflower grow better on somewhat acid soils than do beets, onions, spinach, cucumbers, eggplant, pepper, lettuce, and celery, which do best on soils less acid than that best for strawberries. If the soil is very acid, lime should be applied before one of the rotation crops, as liming just before planting strawberries has often resulted in injury.

An example of a good rotation used by many growers in North Carolina is as follows: After strawberries, drill in a nema-resistant variety of soybeans or cowpeas; turn under or harvest, and sow winter oats; plow under or harvest oats in the spring, and plant soybeans or cowpeas again; plow under or harvest, and plant strawberries in winter. Crotalaria is often used as a cover crop in Florida.

FINAL PREPARATION FOR PLANTING

Because in most of the area to which this bulletin applies the land is low and the drainage often poor, the strawberry plants are commonly set on ridges 3 to 12 inches above the furrows which separate them, as shown in figure 5. Methods of plowing that will form suitable ridges and furnish good drainage should be employed.

The height and width of the ridges will depend on the character of the soil and on the slope of the field. Unless the conditions are

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unusual, ridges 6 to 9 inches above the bottom of the furrows are sufficient. The width of the ridges, which differs greatly in different sections, is further considered under "Planting and training systems." Figure 5, *A*, shows the ridges thrown up and being planted. The tops of the ridges are usually leveled with a plank drag, as shown in figure 5, *C*. Relatively small, narrow ridges are also shown between the wider planting ridges and in the center of what later will be the furrows. The earth from these will be thrown on the sides of the planted ridges to make them wider, as shown in figure 5, *B*.

FIGURE 5.—*A*, This field has been plowed into ridges and is being set to strawberries. The raised beds help the drainage on wet land. (Photographed at Independence, La., November 17.) *B*, The strawberry plants have been set on the raised beds. In the background, piles of pine needles are seen, which will be used for mulch. (Photographed at Independence, La., January 28.) *C*, The tops of the ridges are being leveled with a plant drag attached to a cultivator, before the plants are set. (Photographed at Mount Olive, N. C., May 28.)

GROWTH OF THE STRAWBERRY PLANT

Healthy strawberry plants set in a moist soil produce new fine fibrous roots within a few days. For this reason they may be set in

winter, spring, summer, or fall. If normally cool weather prevails in late fall or in winter they may be set with all the leaves left on and grow better than do those with the leaves taken off. In the spring and summer all the leaves should be taken off or a great amount of care taken to reduce water loss from the leaves by such means as shading or spraying. New leaves appear almost as soon as the roots. If the new root system is extensive, the new leaves are large and several in number. If the plants are set from about March 1 to April 1, 30 to 75 days later runners appear from buds in the leaf axils and continue to be produced until October or a little later. When the days shorten to about 12 hours in the fall, the growing points in the crowns of the oldest and largest plants start changing into fruit buds. In the Northern States the change into fruit buds occurs mostly in September and relatively quickly. In the area covered by this bulletin, fruit-bud formation occurs later, is spread over a much longer period, and is affected far more by environmental conditions. Daylight periods of about 12 hours or less and cool temperatures are most important in fruit-bud formation. Each variety has a different day-length, cool-temperature requirement. The Missionary has the highest, the Klondike a cooler, and the Blakemore a still cooler temperature requirement; the Missionary the longest, the Klondike a shorter, and the Southland a still shorter day-length requirement. The effects of the day-length temperature interrelations on varietal adaptation are discussed on pages 38 and 39.

The change into fruit buds occurs in the oldest and strongest plants first and in the youngest and smallest plants last. In any plant the growing point of the terminal crown changes first and then those of lateral crowns. If the plants are growing very vigorously, the change may possibly occur slightly later, but the resulting fruit buds and the individual flowers and berries are larger, and new crowns that form fruit buds are formed as long as the growing conditions remain favorable. Records of many plants with different numbers of leaves have consistently shown that the greater the number of leaves on a plant late in the fall, the greater number of berries it will produce. Thus, at Willard, N. C., 4-leafed Blakemore plants averaged 22 flowers, 8-leafed plants averaged 44 flowers, and 9- to 11-leafed plants averaged 52 flowers each. In Maryland, plants of another variety with 4 leaves averaged 42 berries, with 11 leaves 102 berries, and with 42 leaves 230 berries (fig. 6). Every practice, therefore, should be directed toward obtaining the largest possible individual plants in the fall.

In Florida, fruit-bud formation is followed immediately by the development of the fruit buds into flower and fruit clusters. Farther north the flower clusters do not appear until February or March, or if a period of cool weather is followed by warm weather in midwinter the flower clusters that develop may be killed. However, the warm-weather conditions that push out flower clusters also enable the plants to develop more fruit buds to replace those that are killed. The first flower to open on a cluster contains the most pistils, is the largest, and develops into the largest fruit with the largest number of seed; the next flower develops into the second fruit in size and the later flowers into successively smaller berries. The flowers are pollinated chiefly by bees. The berries mature in about 30 days after bloom with moderate weather, slower with cool weather, and more

quickly with warm weather. When the flower clusters are borne on a tall stem the plant is not so likely to produce more clusters, and runners are to be expected. In central Florida the flowering season

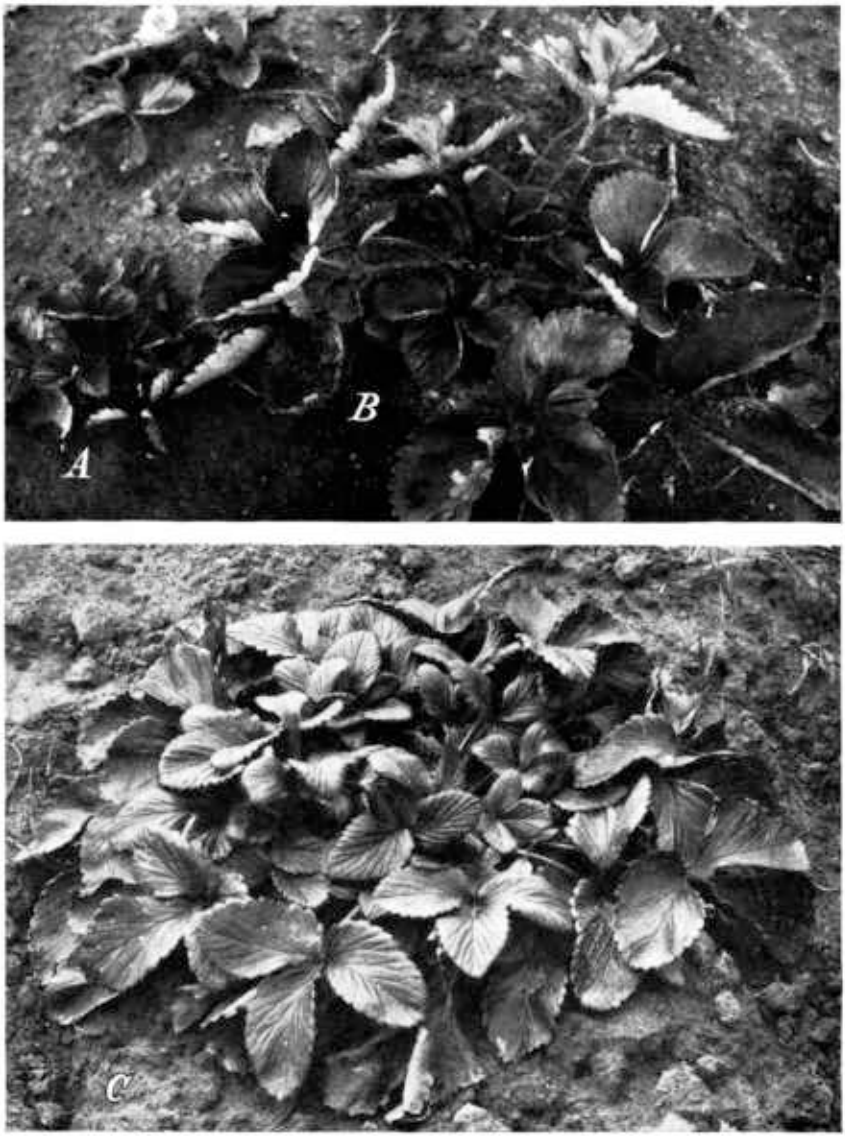

FIGURE 6.—*A*, a small 6-leafed plant. *B*, a large 10-leafed plant. *C*, a large plant with over 40 leaves. In North Carolina, plants such as these may be expected to produce as follows: 6-leafed plants, 30 to 40 berries; 10-leafed plants, 90 to 100 berries; 40-leafed plants, 200 to 250 berries.

may be from December 1 to March 1, or even later in years with cool winters. In the North the flowering season is only about 2 weeks long.

ESTABLISHING THE PLANTATION

In Florida, because of the nema and other troubles, the growers usually obtain a limited number of plants each year from northern nurseries. These plants are set during the winter, about 3 feet apart in rows about 4 feet apart, and serve as mother plants, from which the plants are obtained that in due course make the fruiting plantations. Thus fresh stock is brought annually from regions not infested with nemas and other troubles more or less prevalent in the South, which would soon become serious in the fruiting plantations if the new stock of plants was obtained year after year from local sources.

OBTAINING PARENT PLANTS FROM THE NORTH

The manner of handling the mother plants and of obtaining the stock for fruit production, together with the time of performing the various operations in Florida, is about as follows:

January to March.—New "mother plants" from northern sources are obtained and set. These should start into growth at once.

June to July.—By this time the mother plants set from January to March should have developed enough runner plants to set a considerable area.

August.—The runner plants from the June setting should be ready for planting a more extended area.

September to November.—In turn, the June- to July-set plants should have developed runner plants. These plants are now set to form the main fruiting plantation.

The exact time of making the original planting and the transplanting of the runner plants naturally varies with weather conditions. The months given, however, are those in which the transplanting usually is done if moisture conditions are favorable or are under control (as when an overhead sprinkling system of irrigation is used). A field set in February to be used as a propagating bed is shown in figure 7, *B*.

Some growers prefer to leave the bed made by runners from the original plants until September and then attempt to encourage the development of vigorous runner plants to be set in the plantation and to bear fruit. This practice, however, has not been found as satisfactory as the one previously described, and the number of plants that must be brought from the North for the original planting from January to March is larger than is necessary when the transplanting is done in June. About 1,000 plants are set in February for each acre to be planted in the fall.

By following the practice first discussed it is possible to obtain enough plants to set a large fruiting area from a small original stock of plants. Moreover, plants raised in Florida in this manner will have larger crowns and will bear much better than those brought from the North in October or November and set at once to fruit the following winter. In general, growers have found the latter method unprofitable.

RAISING FRUITING PLANTS

In the Louisiana strawberry district the plants used at present are propagated from local stock. A part of the old field which has fruited is kept free from weeds, and the runner plants from this bed are set in the autumn. Figure 8 shows a field at Hammond, La.,

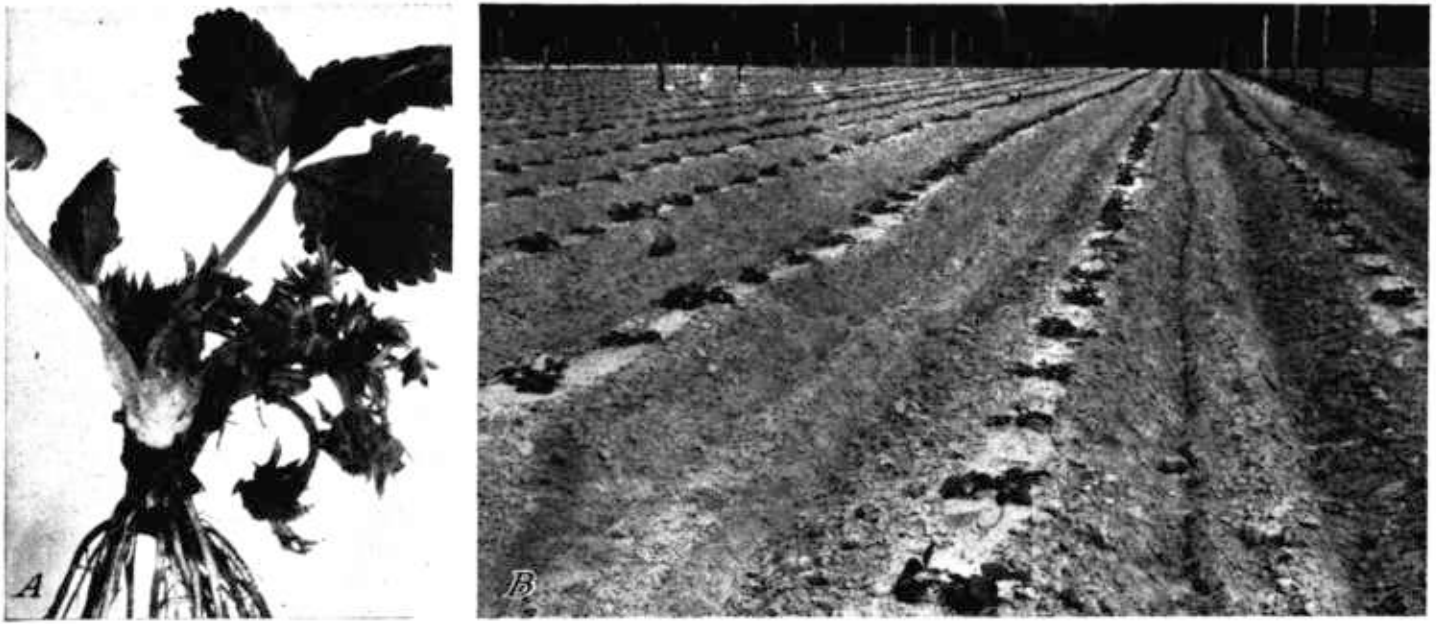

FIGURE 7.—*A*, A plant of the Missionary variety with the first cluster of 11 flowers and buds all killed by severe cold but with a smaller second cluster (9 buds) and a third (very small) cluster not killed. Weather conditions that induced winter flowering also enabled the plant to develop more fruit buds to replace those that were killed. *B*, These strawberry plants were brought from the North and set in February. By the first of June they will have made a dense mat of plants that will be used to set out a larger propagating bed. The plants grown on this plot will be set on a still larger area in August, and these will produce the plants that will be set in the fruiting beds in October and November. (Photographed at Plant City, Fla., March 27.)

FIGURE 8.—Mulch has been raked from strawberry plants and is stacked for use another season. The old plants have been cut out, and from the remaining ones the plants to be set in the autumn will be propagated. (Photographed at Hammond, La., June 15.)

which is to be used as a propagating bed. The mulch has been raked up and the weeds and poorer plants dug out. By November a wide bed of plants should have formed. Some of the most progressive growers transplant the runner plants in July, and from this new bed raise plants that are set later to make the fruiting plantation.

As the nema is common in Louisiana, plants not obtained from northern sources should come from fields free from this pest. Runner plants produced by plants obtained from northern sources should be set in July in order to produce additional runner plants for setting the fruiting plantation later in the season.

In some parts of Texas plants for the fruiting plantation are secured each year from northern nurseries. Growers who follow this course believe that they obtain better results than by using their home-propagated plants. In other localities plants are either propagated year after year from those locally grown or a stock is brought every few years from the North. Unless their home-grown plants are free from nemas, growers in these sections should be able to increase their yields by obtaining their stock from the North each year. The northern stock should be healthy and should be grown in soil free from nemas. Florida growers have found it necessary to obtain plants from as far north as Maryland and Arkansas, and probably would prefer to get them from still farther north if they could be dug and shipped in the winter.

Practices suggested for obtaining plants for districts other than those in Florida, which are given above, are:

North Carolina, Alabama, Mississippi (except Bay St. Louis), and Tyler (Tex.) districts.—Obtain plants in February and March from the North or from local fields known to be free from nemas. Use them to set permanent fields.

Hammond (La.) and Bay St. Louis (Miss.) districts.—Follow either the first or second method specified below:

(1) January to March: Set mother plants from the North. June 15 to July 15: Use the best of the runner plants produced by those set from January to March to set a larger area of stock plants. October to December: Use the best of the runner plants produced by those set in June or July to set the fruiting plantation.

(2) May: Cultivate and weed out the bearing field or a portion of it immediately after the picking season. June 15 to July 15: Use the best of the runner plants from above to set a new plantation for making plants. October to December: Use the best of the runner plants from the field set in June or July to set the fruiting plantation.

Houston (Tex.) district.—December to March: Obtain plants from the North in sufficient quantity and set the permanent fruiting plantation.

TIME OF PLANTING

In general, the planting seasons have already been indicated. Where the hill system (to be described later) is used, however, certain facts should be remembered. In Florida the best time to set plants from which the crop is to be produced is the last of September. Those set in the latter part of October begin to bear earlier than those planted in September or those set in August, and growers use this characteristic to regulate the bearing season to some extent.

In the Hammond district the plants set in November are usually better than those set at other times, whereas those set as late as December 20 may be satisfactory. Figure 9 shows part of a field at

FIGURE 9.—Strawberry plants set in single rows on slightly raised beds. The plants in the row at the right were set in October, and those in the rows at the left were set on December 22. Though November-set plants are usually the most satisfactory, in this case the later set plants were better, produced more fruit, and required less tillage. (Photographed at Hammond, La., April 14.)

Hammond in which the rows to the left were set on December 22 and those to the right in October of the same year. Because of weather conditions, which affected their growth, the plants set in October did not grow or produce as well as those set in December, and they required more tillage.

PLANTING AND TRAINING SYSTEMS

Three systems of growing strawberries are generally used in the South—the hill, the spaced, and the matted-row systems. The map shown as figure 1 indicates the sections in which each system is principally used.

Hill System

Under the hill system the plants are commonly set in late summer or in the autumn, and the crop is harvested during the winter or the following spring. Usually plants set at that time make no runners, but if any do appear they are removed. When this system is used, the plants may be set in single, double, or triple rows, as shown in figure 10, *A*, *B*, *C*, and *D*.

The single row is generally used in the central Florida sections, in the Hammond, La., district, and in the Chadbourn district of North Carolina. The plants are usually set about 1 foot apart in rows 3 feet apart, as shown in figure 10, *A*. Occasionally the rows are set 3½ feet apart.

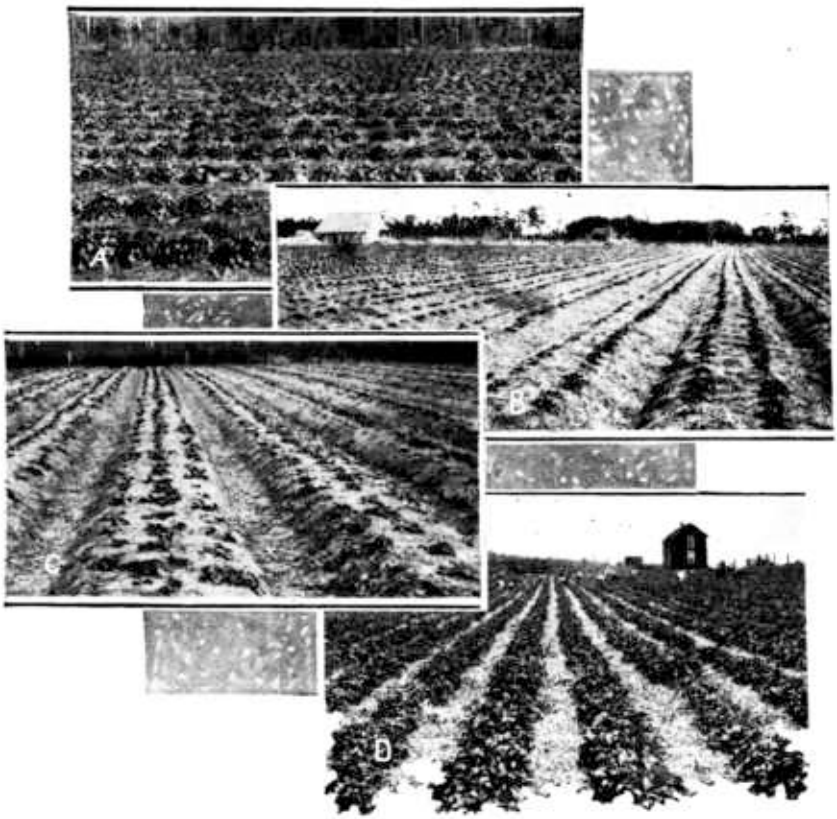

FIGURE 10.—*A*, Strawberry plants trained to the hill system. The plants were set 1 foot apart in single rows, 2½ to 3 feet apart. All runners were kept off. (Photographed at Plant City, Fla., February 3.) *B*, Strawberry plants set in two rows on each raised bed. The plants are 14 inches apart in the rows, which are 22 inches apart. The alleys between the beds are 32 inches wide. (Photographed at Starke, Fla., February 6.) *C*, Strawberry plants set in three rows on each raised bed. This plan is rarely followed except in the Starke, Fla., region, though occasionally elsewhere. (Photographed at Hammond, La., November 22.) *D*, Strawberries in narrow, matted rows, well-grown, and mulched with straw. Under this system plants are set commonly in winter or early spring 18 to 40 inches apart in rows 3½ feet distant. The runners are allowed to root.

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In the northern Florida section, and to some extent in others, the double-row system is preferred. In northern Florida the rows are set 20 to 24 inches apart, and an alley 2 to 3 feet wide is left between pairs of double rows, as shown in figure 10, *B*. Where double rows are set in central Florida and in Louisiana, these rows are 12 to 15 inches apart and the alleys 3 to 4 feet wide. The wider beds on which two rows are set allow more plants to the acre and more of the field is in beds than when single rows are used.

Except in the Starke section of Florida, triple rows are rarely used. There three rows are often set 20 to 24 inches apart on each bed. If the drainage is good, this plan may be used. One very successful grower in Louisiana has set his plants in triple rows with the plants 12 to 14 inches apart each way. His plan is illustrated in figure 10, *C*.

Matted-Row System

Under the matted-row system the plants are usually set in the winter or early spring, 18 to 40 inches apart in rows 3½ to 6 feet apart, and the runners are allowed to root. The interval at which the plants should be set in the row depends upon the probable danger of losing plants through drought or insects. If there is little danger, the plants may be set 40 inches or more apart, and runner plants may be trained to form a solid mat in the spaces between plants. Where loss is likely, the plants should be set about 18 inches apart.

The matted-row system is commonly used in the Wallace and Chadbourn districts in North Carolina, in Alabama, in all the Mississippi districts except Bay St. Louis, and in the Houston and Tyler districts of Texas. Figure 10, *D*, shows a field grown under the matted-row system.

Spaced-Row System

A spaced row is one in which the runners are placed or set by hand until the desired stand is obtained, and then either the later-formed runners are removed as they appear, or all the surplus runners are removed at one or more times, so that the plants left to fruit are spaced at a fairly uniform distance. In the final stand the plants are 6 to 12 inches distant and the rows 24 to 30 inches wide. A modification of the matted row, sometimes called a spaced row, is formed by allowing all the runners to root and, after enough are well rooted, by raking across the rows with a steel-toothed horse rake or a spike-tooth harrow with the teeth slanting back. Finally, a cultivator with a circular disk next to the row is run down the rows to cut off surplus runners. Of course a thin stand of plants in an unspaced matted row is about the equivalent of such a thin matted row.

In a comparison of systems of training at Willard, N. C., the Blakemore variety was used. By November 1, the matted row had set a dense stand of plants, by actual count over 30 plants per square foot. Such plants were crowded and had few leaves per plant; the leaves were small; and many plants produced no berries the next year. The spaced plants in the 24-inch-wide rows and the double-hill row were large and produced a good crop the following year, as shown in table 1. The yield was greatest in the 9-inch spaced row, the size was greatest in the double-hill row (fig. 11), and the decay 1 day after picking was least in the double-hill row. In this test, with a

drought toward the end of the season, the percentage of marketable berries went as low as 18 percent for the 30-inch matted row, whereas it was 90 percent for the double-hill row. Similar results have been obtained in other regions. The cost of growing an acre in spaced rows is higher than in matted rows, and in deciding which system to use the cost must be considered against the returns.

FIGURE 11.—A single picking from three rows of Blakemore strawberries to show the difference in the grades produced under different systems of management. *A*, Three boxes containing 2 quarts from a 30-inch wide matted row, graded into culls (front row), U. S. No. 1 (second row), and large (third row). *B*, 6 boxes containing 4 quarts of berries from a row with plants placed 9 inches apart. *C*, 6 boxes containing 4 quarts of berries from a double-hill row with plants formed early. At this picking there were no fancy and but few large berries from the matted row (*A*), nearly 1 quart of fancy and 1½ quarts of large berries from the double-hill row (*C*), and over 2 quarts of large and fancy berries from the 9-inch spaced row (*B*).

TABLE 1.—*Yield in quarts per acre, percentage of U. S. No. 1 and culls, relative size, percentage of decay after 1 day, average number of leaves formed per plant by Nov. 1, number of leaves per foot of row on Nov. 1, and number of plants per foot of row of Blakemore strawberries under five systems of growing at Willard, N. C.*

Growing system	Yield per acre			Relative size	Decay after 1 day	Average leaves per plant Nov. 1	Leaves per foot of row Nov. 1	Plants per foot of row
	Total	U. S. No. 1	Culls					
	Quarts	*Percent*	*Percent*	*Percent*	*Percent*	*Number*	*Number*	*Number*
9-in. spacing, 24-in-wide row	4,993	84	16	88	8	9.2	45	1.8
6-in. spacing, 24-in.-wide row	4,760	80	20	80	10	7.0	70	4.0
Double-hill row	3,506	90	10	100	5	10.0	10	.7
30-in. matted row	2,331	57	43	62	26	3.0	220	30.0
12-in. matted row	2,098	68	32	72	16	.....	120	.....

NUMBER OF PLANTS REQUIRED TO SET AN ACRE

Table 2 shows the number of strawberry plants needed to set an acre of ground when spaced according to the systems commonly used.

Where there is little danger of loss of plants, only the number specified above will be needed. If there is considerable danger of loss, a somewhat larger number should be obtained, in order to insure a full stand, as the expense of caring for a field which has many blank spaces will be out of proportion to the value of the crop obtained.

TABLE 2.—*Number of strawberry plants required to set an acre of ground when spaced at different distances apart*

Distance apart	Plants to the acre	Distance apart	Plants to the acre
2 by 1 foot	21,780	2½ by 1½ feet	11,616
2 by 1½ feet	14,520	3 by 2 feet	7,260
3 by 1 foot	14,520	3 by 3 feet	4,840
3½ by 1 foot	12,446	3 by 4 feet	3,630

CARE OF PLANTS BEFORE SETTING

Good plants in bundles of about 25 each as they are received from the nursery are shown in figure 12. They should be kept cool and moist until set. If they are to be set the day they are received or the following day, they should be placed in the shade and covered with wet burlap. If, however, they cannot be set for several days,

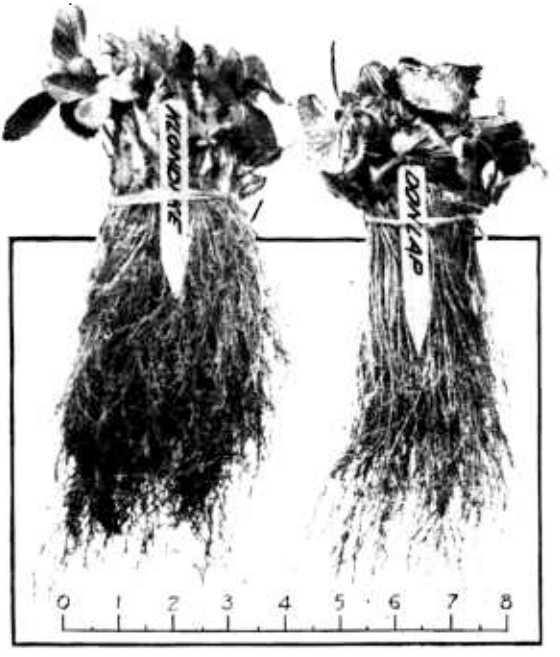

FIGURE 12.—Good Klondike and Dunlap strawberry plants, in bundles as they are commonly received from the nursery. Each bundle is supposed to contain 25 plants.

the bundles should be opened and the plants separated and heeled in, as shown in figure 13.

The plants should not be dropped far ahead of the setters, especially on dry, windy days, and the workers dropping the plants should use some means of protecting their supply, as shown in figure 14.

FIGURE 13.—*A*, Heeling in strawberry plants. The bundles are opened and the plants spread out in a trench with the crowns even with the surface, as here shown. *B*, The trench in which the plants have been placed, as shown in *A*, has been filled with moist soil covering the roots, and the soil is being packed firmly about them. Here they are left until wanted for setting in the field.

SETTING THE PLANTS

Plants may be set by hand, with one of several hand tools, or with a machine. For planting large areas a planting machine is cheapest and best. Whatever the method used, two things are of special importance—setting the plants at the right depth and making the soil very firm about the roots.

The plants should be set so that the crowns are even with the surface of the ground after the soil has been packed about the roots. The proper depth for planting is illustrated in figure 15.

If the soil is not properly firmed about them, air gets to the roots, and they are likely to dry out. Besides, plants so treated usually will start

FIGURE 14.—Dropping strawberry plants from a fertilizer sack. A slit is cut for the head near the top and one across the outer side near the center. The plants are placed in the bottom, where they are protected from sun and wind.

a feeble growth or none at all. If the soil is thoroughly firmed very little trouble will be experienced in getting plants to live. Some growers step on each plant after it has been set, in order to make sure that the soil has been properly firmed. When this is done, the instep should come over the crown of the plant in order to avoid injuring it.

Setting by Hand

Setting with the opening made by hand is not often done except in very loose soils, but in such soils this method is very satisfactory. A wedge-shaped opening about 4 inches deep is made in the soil with one hand and the roots inserted with the other. The earth is then drawn about the roots and firmed. Plants may be set quite rapidly in this manner, but the work is hard and the soil seldom sufficiently mellow. The method is used chiefly in sections where the plants are set close together and those setting them do not have to move about much.

Setting With Hand Tools

Growers in most districts use a dibble, trowel, or punch to make openings in the soil for setting strawberry plants. Different sorts of such tools used for this purpose are shown in figure 16. With one of these implements an opening 4 to 6 inches deep is made in the

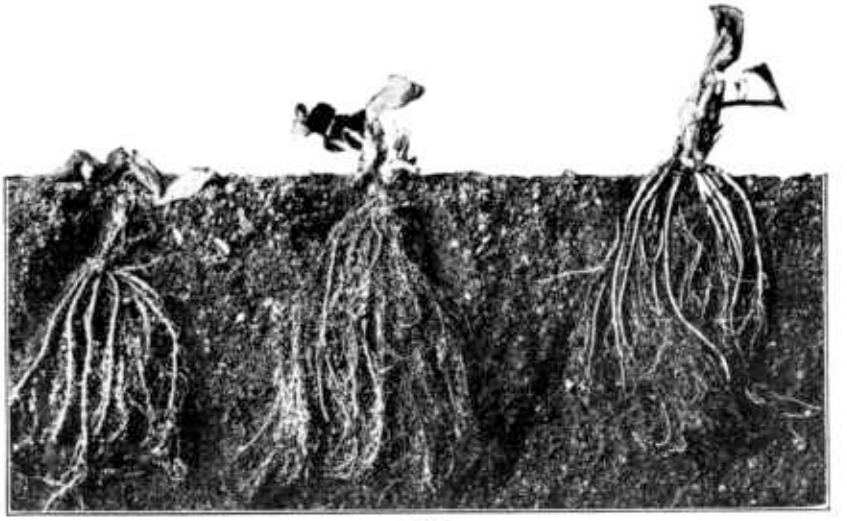

FIGURE 15.—Strawberry plants set at different depths. The plant at the left is set too deep and will be smothered; the one in the center, with crown at the surface, is right; the one at the right is too shallow and will dry out.

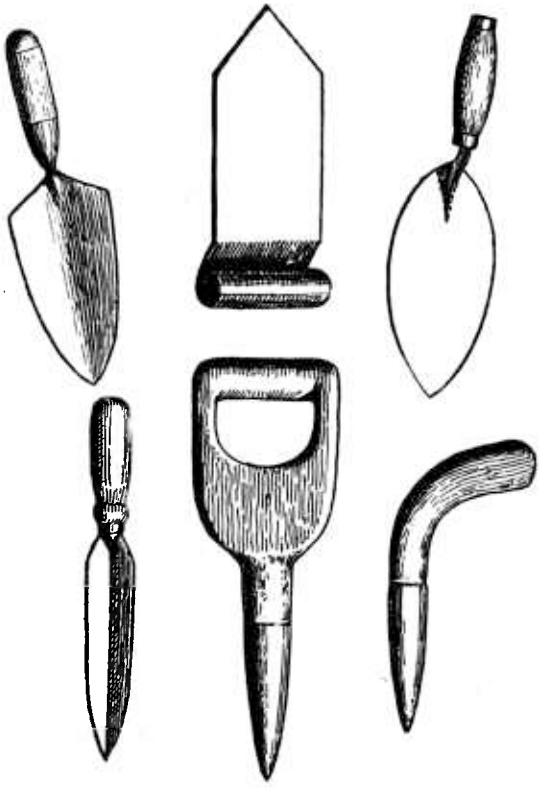

FIGURE 16.—Different types of dibbles, trowels, and punches commonly used in transplanting strawberries. The best for most conditions is shown in the center of the top row.

soil, the roots are inserted, and the earth pressed back firmly about them. When a punch is used one man usually goes ahead making the holes, another follows dropping the plants, and one or two others place the plants in the holes and draw the earth about them. The punch cannot be used readily in soils having straw or stones in them, but is well adapted for use in loose soils. The dibble can be used in any well-prepared soil.

Two men form a crew for setting plants with a spade. One inserts the spade and opens a hole by forcing it forward. After the roots of the plant have been inserted, he withdraws the spade and with his foot presses the soil firmly about the roots. The second man carries the plants and inserts them in the holes as they are made with the spade. Plants can be set rapidly by this method, which is widely used.

A paddle like that shown in figure 17, *A*, is often used. The plants are dropped exactly where they are to be set, and a man following presses the roots into the ground with the paddle and thoroughly packs the earth about the roots with his foot. Plants can be set very rapidly by this method, but the soil must be loose, friable, and moist. A variation of this tool, called a packer, is shown in figure 17, *B*. The plant is pressed into the ground with a paddle and the earth firmed around it with the packer.

Another method of planting is with a punch and tongs, as shown in figure 17, *C*. This method is used more extensively in setting sweetpotatoes than for strawberries. A hole is made with the punch, the plant is picked up with the tongs and placed in the hole, and the earth firmed with the foot. A man experienced in the use of this tool can set 10,000 plants a day with it, while an expert can set many more. Under favorable soil conditions it is easier to set 10,000 plants a day in this way than to set 5,000 with a dibble or trowel.

Setting With Machine

On smooth land planting machines used in trucking sections for transplanting tobacco, tomatoes, cabbages, sweetpotatoes, and the like are often used to set strawberry plants. The soil should be moist or water must be applied when the plants are set with a machine. Usually one man drives the machine and two others feed plants into it. A fourth man prepares the plants for the machine. About 30,000 plants a day, or 3 to 5 acres, can be set in this way.

The chief difficulty in the use of a planting machine is that it is difficult to set all the plants at the right depth. After some practice, however, intelligent droppers become so expert that practically all plants are set at the proper depth with the roots straight down and are set better than by hand. A roller attached to the planter may be used to firm the soil, or a man may walk along the rows and firm the plants with his foot. When all conditions are favorable, especially in sections where cool, moist weather may be depended upon for some time after the plants have been set, such a machine may be used very successfully, and the cost of planting will be comparatively low.

FIGURE 17.—*A*, Setting a strawberry plant with a paddle. This method is adapted to places where the soil is very mellow. The plants are dropped in place, the roots are forced into the ground with the steel-tipped paddle, and the soil is then firmed about them with the foot. *B*, Setting a strawberry plant with a packer. The roots of the plant are forced into the ground with the paddle, and the soil is firmed about them with the packer attached to the handle of the paddle by clips, which allow it to be worked up and down. *C*, Setting a strawberry plant with punch and tongs. A hole is made with the punch, the roots of the plant are placed in it with the tongs, and the soil is firmed about them with the foot.

CARE OF PLANTS AFTER SETTING

REMOVING FLOWER STEMS

Flower stems usually appear on winter- or spring-set plants soon after they are set. Until the plants become firmly established after transplanting, fruit production is a severe drain on their vitality. Therefore, the flower stems should be removed as they appear. Furthermore, when a very large number of plants is needed, the flower stems should be removed, since the runners will increase more rapidly, and better plants will be produced than if fruit is allowed to develop. Because experiments have shown that early-formed runner plants produce the most fruit the following year, removal of flower stems can materially help in getting early runners.

WIDTH OF MATTED ROWS

In general, matted rows should not be more than 24 inches wide, and many growers find that 12 to 15 inches is better than a greater width. It is easier to harvest the berries from narrow rows, and most varieties of strawberries, and especially the Blakemore, produce better in narrow rows. If the row is more than 2 feet wide, some ripe berries along the center are likely to be overlooked by the pickers, and unless the plants are well spaced many berries are likely to be small. Matted rows are ordinarily less than 2 feet wide.

It will often be necessary to thin the plants in matted rows during the summer and autumn. For this purpose, roller cutters may be attached to the cultivator, so that all runners extending more than a certain distance into the alleys will be cut off when the cultivating is done. Surplus runners may also be removed when the field is hoed.

Where the matted row is 2 feet in width, growers, in addition to attaching cutters to the cultivator, sometimes run a bull-tongue plow with a point about 4 or 5 inches wide down the center of each row, tearing up the center plants. This leaves the row cut into two parts in what might be called a double-matted row.

SPACING PLANTS

Under the spaced-row system of culture, the runner plants are spaced by hand rather than allowed to root at will. The exact distance and plan of spacing should be determined by local conditions. As soon as the tips of the first runners begin to enlarge, they should be placed in the rows between the mother plants, or to the side, as shown in figure 18, and covered with soil. The next ones should be placed 6 to 12 inches out from the original row and on each side of it. Additional runners may then be rooted until a wide row has been formed, with the plants at least 6 inches apart. Thereafter, all runners should be cut off as they develop.

TILLAGE

In the Florida districts it is necessary to keep down weeds and maintain the soil in good physical condition until the mulch is put on, which in the central Florida district is usually some time in December and in the Starke district in January or February. One-

horse cultivators and hoes are used largely in cultivation before the mulch is applied, but hoes only after the mulching is done.

In the Louisiana district weeds should be kept down and the soil maintained in good tilth by hoeing and cultivating until cold weather sets in. As certain weeds grow vigorously throughout the winter, much hoeing is necessary during that period. The weeds must be scraped from around the plants, as shown in figure 19. At this time

FIGURE 18.—A double-hill row completed before the end of July. The runner plants are rooted about 12 inches apart in the row to make double rows about 12 inches distant. To make wider spaced rows, runner tips are rooted to the sides of the rows shown, at any desired distances. Plants such as these with 6 leaves by August 1 may have 20 or more leaves by the end of the growing season and produce at the rate of 400 or more bushels per acre.

or as soon afterwards as possible, a horse cultivator should be run in the alleys. If weeds continue to grow, the alleys should be hoed or a shallow cultivation given. Great care should be taken to keep the alleys open, so that water may drain off freely and the strawberry roots be disturbed as little as possible. In this district the mulch is usually applied during February. If weeds develop after this time they should be kept down with a hoe. In both hoeing and cultivating,

FIGURE 19.—A common practice in southern Louisiana is to hoe or scrape the weeds from the rows of plants into the middles. This is done late in January or in February, and pine-straw (needles) mulch is then applied. (Photographed at Independence, La., January 29.)

the soil should be worked toward the plants, not away from them. Growth of new leaves takes place at the top; so the crown grows out of the ground, though slowly. All new roots from the crown grow out at the base of the new leaves, and because they are readily killed by dry air it is important that moist soil be both hoed and cultivated toward the plants and new roots given a chance to form.

In sections other than those in Florida and Louisiana tillage should begin immediately after planting and continue each week or 10 days until late autumn or into the winter when the mulch is applied. This late tillage will keep down the weeds, so that little or no hoeing will be necessary in the spring.

COMPANION CROPPING

In order to obtain returns from the land during the first summer after spring planting of strawberries, vegetables are frequently grown along the rows or in the alleys between them as companion crops to the strawberries. This practice is followed especially where the matted-row system is used.

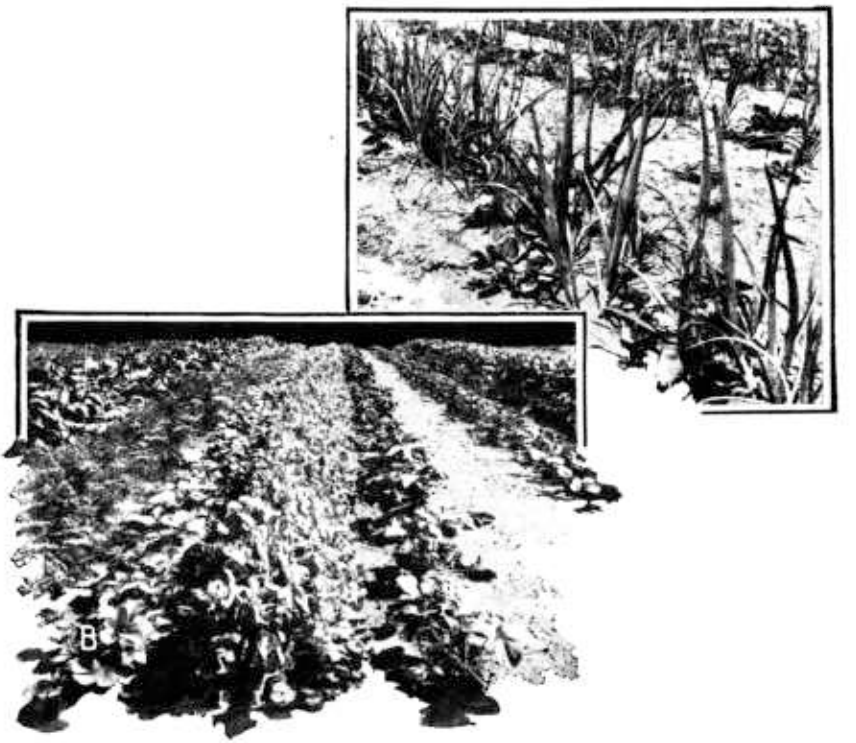

FIGURE 20.—*A*, Strawberries with onions as a companion crop in the rows. The onion sets are planted in the spring and removed early in the summer, leaving all the space for the strawberries. *B*, Strawberries with companion crops between the rows. At the left, lettuce, carrots, and beets alternate with the rows of strawberries; radishes have been harvested at the right; and beans are growing at the extreme right. The extra fertilizer and careful culture given these companion crops are an advantage to the strawberry plants.

Nearly all kinds of vegetables may be raised in this way, and the thorough cultivation given them will be sufficient for the strawberry plants. Most vegetables, however, are susceptible to root knot nemas, and care should be used to see that infested plants are not set in the strawberry plantation. Vegetable seeds do not commonly carry nemas.

Onions may be grown in the strawberry rows, as shown in figure 20, *A*, and such quick-maturing plants as lettuce, radishes, peas, and carrots may be grown between the rows, as shown in figure 20, *B*. The strawberry rows are planted the same distance apart as under ordinary conditions. The vegetables are removed before the strawberry plants begin to spread over the ground to any extent.

When such crops as beans, peas, and cabbage are grown with strawberries, special systems of planting the vegetables are often used. Cabbage or cauliflower may be set about 6 inches to one side of the strawberry row. The strawberry plants will be shaded to some extent by the leaves of the cabbage or cauliflower, but when the vegetables are removed during the summer the strawberries will spread over and occupy the whole space.

When beans are used as a companion crop, the strawberry rows are usually set somewhat farther apart than in ordinary practice and the companion crop planted in the middle of the alleys between the rows. The strawberry rows should be spaced at least 4 or 4½ feet apart and only a narrow mat of plants allowed to form until after the beans are harvested. Potatoes or corn should not be used as companion or preceding crops because of danger of loss from verticillium wilt and from root aphids, respectively.

STRAWBERRIES AS AN INTERCROP

In many sections, strawberries are grown as an intercrop in peach, apple, fig, orange, or other tree-fruit orchards. When the orchard is first planted, strawberries may be set out and grown for several years before the trees will need all the ground. When this practice is followed, the strawberries may furnish some income from the land or at least may pay the expense of caring for the orchard. The intensive cultivation given strawberries is especially good for young orchards, and as strawberries do not bear well unless the moisture conditions are good, they may prove a good indicator of these conditions.

MULCHING

A mulch is used in most strawberry fields in the South. Its principal uses are to keep the berries clean, to prevent decay, to conserve moisture, to protect the flowers from frost, and to keep down weeds. The mulching materials most commonly used in the South are pine needles, wild hay, and wheat, rye, and oat straw; all are satisfactory. When pine needles are used they are raked during the winter and are usually stacked along one side or on both sides of the field.

In nearly all parts of the South the mulch is applied just before the blossoms open. Where the hill system is followed the mulch is distributed over the fields by hand from a handcart, as shown in figure 21, *E*, or from a rack, as shown in figure 21, *C*. Where the matted-row system of culture is used the mulch is generally placed

in windrows and spread by hand, as shown in figure 21, *A* and *D*. Sufficient mulch should be applied so that after settling it will be 1 to 3 inches deep. This will require several large two-horse hayracks of material to the acre.

In the central Florida district, the mulch is used not so much to keep the berries clean as to protect the flowers and fruit from frosts. In this district the mulch is put in the alleys, and when there is danger of frosts it is spread over the plants. A small quantity of pine needles, wild hay, or straw will afford protection from ordinary frosts, though the temperature over a mulched field is lower, other things being the same, than over an unmulched field.

FIGURE 21.—*A*, The strawberry field shown in *D*, when partly mulched. This shows how the straw was thrown off the wagon in windrows and then scattered over the rows. *B*, Strawberries mulched heavily, not only to conserve moisture and to keep the fruit clean but to protect the blossoms from late frosts by covering the plants with the extra mulch between the rows. (Photographed at Starke, Fla., March 29.) *C*, Scattering mulch by hand over the strawberry field. This method involves more labor than that shown in *D*. (Photographed at Starke, Fla., February 6.) *D*, Mulching the strawberry field with wheat straw thrown from a wagon. This method is more rapid and less laborious than handwork. *E*, A handcart for scattering mulching material over a field of strawberries.

Where a mulch is used, some of the berries are likely to be lost through cricket injury at the beginning of the strawberry season. The crickets hide in the mulch by day and at night eat the ripening fruit. Unless partly eaten berries are picked, they may rot and spread disease to neighboring berries. The damage done by crickets is not often serious, and may be largely prevented by scattering along the rows poisoned bran mash made by mixing 1 pound of white arsenic and 12 pounds of bran in water.

FROST PROTECTION

In nearly all parts of the area to which this bulletin applies, the loss due to frosts is more than that in most other sections. Actual records in a well-spaced planting in North Carolina in 1938 indicated that an average of 6.2 flowers per plant had been killed by frosts. This is not unusual, and more may be killed in some seasons. However, the first flowers to open normally develop into the largest berries, and 6.2 berries per plant represent a loss of from 4,000 to 5,000 quarts of the best and earliest berries in a well-spaced planting. Losses in fields with matted beds are sometimes less and sometimes greater than in spaced plantings, but probably average much less because the yields are much less.

Frost injury is most commonly prevented by covering the plants with a mulch. A light covering will protect against most frosts, and hundreds of acres are so covered. In cool weather the flowers can be pollinated over a period of several days, so that the mulch may be left over the plant for 2 or 3 days if frosts are expected on successive nights. V-shaped troughs made of 1-inch by 10-inch and 1-inch by 12-inch cypress, placed on the north side of each row, to be inverted over the plants in case of frost, have proved to be an effective protection in Florida fields. Coverings of muslin, cheesecloth, or kraft paper are sometimes used. Spray irrigation is sometimes used and may be effective, especially when the injuriously low temperatures do not last for more than 3 or 4 hours. Stirring the air by the use of large power-driven fans is being used in frost protection on low areas and is a method of protection worth considering where the conditions for its use are favorable. Oil heaters have been used effectively under some conditions.[3]

USE OF FERTILIZERS

The use of fertilizers on strawberry fields is governed largely by the same principles that apply to their use on other crops. As soils differ greatly in their composition the problem of fertilizers is chiefly local, to be solved by each grower according to his own conditions. Proper fertilizer application can be determined by applying the different plant foods (nitrogen, phosphoric acid, and potash) separately, in different combinations and in different quantities, to small plots and keeping records of the yields from the different plots. In like manner different quantities of stable manure can be applied to different plots in order to test its value.

In the Southern States the Coastal Plain soils of the Atlantic Coast States need large applications of fertilizer. In contrast, however,

[3] See Farmers' Bulletin 1588, Frost and the Prevention of Frost Damage. Out of print. May be consulted in libraries.

most Gulf Coast soils are so well supplied with plant food that good crops of strawberries can be produced with the use of much less fertilizer, provided the soil is kept in satisfactory physical condition by the addition of humus, by adequate drainage, and by frequent tillage.

In the district about Houston, Tex., ordinarily no fertilizer is used under any system of training.

Investigations in North Carolina indicate that nitrogen is the element most important in fertilizers applied to strawberries. Results of experiments indicate that nitrogen may be profitably applied from early in September until December or January. Because of the difference in availability of nitrogen in different fertilizers, the source of the nitrogen is of great importance. Nitrogen from mineral sources, such as sulfate of ammonia and nitrate of soda, is quickly available, whereas that from organic sources, such as cottonseed meal, tankage, fish meal, and Peruvian guano, is available more slowly. It would appear that a fertilizer with a content of 3 to 5 percent nitrogen, part of which is from mineral sources and part from organic sources, would be satisfactory. Because it is dissolved quickly and may be leached out in a short time, if inorganic or mineral nitrogen only is used, best results would be secured from several applications. Sulphate of ammonia tends to make the soil more acid and should not be used if the soil is inclined to be too acid (pH 5.5 or lower). Insufficient nitrogen in the soil results in small crops, and the berries mature much later. Too much nitrogen may make the foliage dense and the berries late in maturing. Very dense foliage and resultant shading may make the fruit somewhat more likely to rot.

In experiments in eastern North Carolina, applications of 60 pounds of nitrogen per acre, half derived from inorganic fertilizer (nitrate of soda and sulfate of ammonia) and half from organic sources (cottonseed meal and tankage), increased yields for 3 years an average of 95 percent (3,144 quarts), whereas the addition of potash (75 pounds of K) and superphosphate (20 pounds of P), or both, with the nitrogen depressed the yields over nitrogen alone by 1,163 quarts.

In the investigations in North Carolina, during 2 years with hot, drying weather, potash applications have appeared to make the foliage of plants stand up much better than the foliage that did not receive potash but that did receive mineral nitrogen. In one season berries treated with phosphorus in addition to nitrogen were much better flavored than those treated with nitrogen only, whereas berries treated with potash were poorer flavored. There was no real evidence that potash or phosphorus tended to make the berries firmer or to increase the crop. In experiments in Arkansas and Texas, however, increased yields have been obtained by the use of phosphorus.

Until more is known about the fertilizer requirements of strawberries it is suggested that a fertilizer with an analysis of about 3 to 5 percent nitrogen, 6 percent phosphorus, and 2 percent potash be used. Experiments made so far indicate that at least half of the nitrogen should be from organic sources. For average conditions in eastern North Carolina an application of 750 pounds per acre early in September and another 750 pounds in December or early in January should be made, or a top dressing of about 250 pounds of nitrate of soda or its equivalent in cottonseed-meal, tankage, or other source of organic nitrogen should be made in the late fall, after the early fall application of the complete fertilizer.

Because potash and phosphorus applied as a top dressing do not move down into the soil to an appreciable extent and, consequently, do not become fully available to the plant, when a mixed fertilizer is applied it should be placed down beside the roots along the sides of the rows after turning a shallow furrow away from the plants. Nitrogen, on the other hand, readily goes down into the soil and if nitrogen only is used a top dressing is very satisfactory.

In Florida, 400 to 600 pounds of about a 5–7–3 fertilizer is thoroughly mixed with the soil in the row, 1 or 2 weeks before planting, or it is applied as a side dressing 10 days after setting. Two applications about 6 to 12 weeks later of about the same quantity are made in Florida, the fertilizer being placed between the double rows or along one side of a one-row bed. In Louisiana, 1,000 pounds of a 4–12–4 fertilizer has been recommended.

USE OF LIME

Lime may help in several ways in a strawberry field. It serves as a source of calcium, and, if the lime is in the form of dolomite, as a source of magnesium also. Lime also lessens the acidity of the soil. Strawberries usually grow well on light soils when the acidity measures between pH 5.5 and 6.5, but they may still grow well between pH 5.0 and 7.0 if there is a high content of organic matter in the soil. On heavy soils the range for good growth is somewhat greater. Where the pH is 5.3 to 4.5, lime is needed, and an application of 1,000 pounds (light soils) to 2,000 pounds (heavy soils) of lime per acre is suggested. Where the soil is pH 4.5 or below, 1,500 pounds (light soil) to 3,000 pounds (heavy soil) is suggested. This ties up free aluminum, which is toxic to strawberry plants, and makes available calcium and magnesium. Such an application may also help to put the soil in a better state of tilth. Lime must be applied with care, for an excess is harmful, dwarfing the plants and reducing the size of the berries. It is best applied a year or two in advance of strawberries and disked or plowed into the soil.

IRRIGATION

Droughts during the long growing season occur so often, and the loss from drought is so often serious, that frequently it will pay to irrigate strawberries. Many growers have done so. Either the spray [4] or the surface system may be used, according to local conditions. At present the spray system is most often used in Florida, and surface irrigation in Louisiana and Texas. The overhead-pipe system is expensive to install, costing from $80 for a portable pipe system to $400 or more for new permanent equipment per acre. It is especially valuable in Florida for propagating plants. A recently developed type of sprinkling irrigation with whirling sprinkler heads and portable pipes with jiffy couplings is now available. Costs for this have been reported as low as $35 per acre.

Water for surface irrigation is usually secured in the Hammond district of Louisiana from artesian wells and in the Houston district in Texas by pumping from bayous, streams, and lakes. In Florida,

[4] See Farmers' Bulletin 1846, Supplemental Irrigation.

water is obtained both from wells and by pumping from lakes and streams. A flowing artesian well provides a continuous water supply, and after the well is bored the only cost is in distributing the water in the field. Irrigation is used in summer, when drought occurs, in order to save the propagating beds; at planting time it is frequently applied to moisten the soil for setting; and again during the fruiting season in order to counteract drought.

When the water is being applied in surface irrigation the alleys should be free from obstacles. The rows should be not more than 500 feet long and preferably not over 300 feet, so that the water can run down the alleys without too great loss. During the planting and picking seasons water should be run down every other alley, as shown in figure 22, so that the workers may walk in the unirrigated

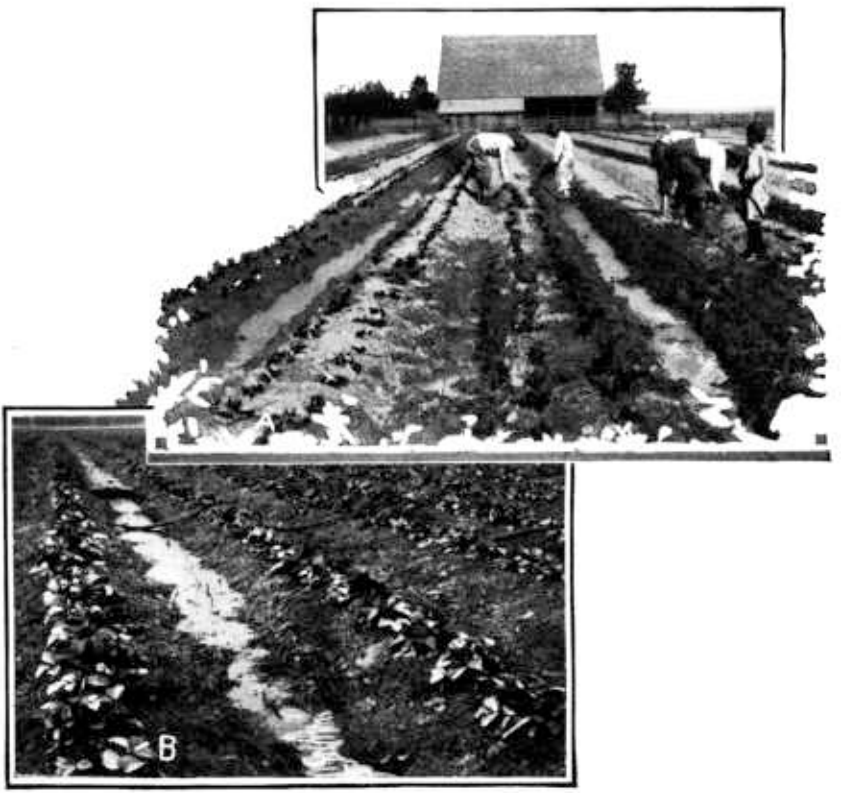

FIGURE 22.—*A*, Setting strawberries under irrigation. Water is run down every other alley, leaving the alternate ones dry for the convenience of those who are setting the plants. Note that double rows are set on the ridges. (Photographed at Hammond, La., November 21.) *B*, Strawberries being irrigated during the picking season. Water is run down each alternate alley, leaving dry spaces for the pickers. (Photographed at Ponchatoula, La., April 13.)

furrows. At the next irrigation the alleys previously omitted should be watered, thus alternating at each application. Wherever possible, the irrigated alleys should be cultivated about 2 days after each irrigation, if the soil is in suitable condition for working.

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In the Houston district the expense of installing and keeping up pumping stations is considerable. Furthermore, there is no season when heavy rains may not be expected, and if an irrigation is followed by heavy rains, the plants may suffer severely. For these reasons, irrigation is used somewhat less than it was formerly; but as severe droughts are common many growers have found some irrigation necessary, and it is used more or less in the summer, at planting time, and at the harvest season, the last especially as an aid in keeping up the size of the fruit as harvesting progresses.

RENEWING THE PLANTATION

Where the hill system is used, the plantation is rarely renewed, but is plowed up at the end of the first fruiting season. The cost of renewing under the matted-row system is usually less than that of setting and caring for a new plantation. Therefore, where the matted-row system is used, the fields are kept from 2 to 5 or 6 years, or as long as they produce profitable crops. The length of time a plantation may be kept profitably depends upon the quantity of humus in the soil and upon the prevalence of diseases, insects, and weeds. If green-manure crops were turned under before the plantation was set so that the soil is in good condition, two or more crops may be harvested before the plantation should be plowed up and a new one set, but if insects, nemas, or diseases do much injury, the field may become unprofitable even though the humus supply is ample. Furthermore, if a field becomes very weedy, it may be more profitable to use the land for some other crop than to keep it in strawberries. Local conditions, therefore, largely govern the length of time a field may be profitable.

In renewing a plantation the field should first be cut over with a mowing machine. If injuries from diseases and insects are not serious, the foliage and mulch should generally be turned under. This will increase the humus content of the soil and put it in better condition than burning. If the mulch is very heavy, however, it may be necessary to remove part of it before plowing. If it is not too much decayed, the mulch is sometimes raked up and stacked for use the following year, and only the strawberry foliage is plowed under. In all sections where renewing is done the aim should be to obtain large, vigorous plants by October, during which month fruit-bud formation begins in much of the South.

Where insects and leaf-spot diseases are prevalent, growers prefer to burn the foliage and mulch in the field. It is then easier to thin the plants than if the mulch and leaves are left. As soon as the foliage has dried, the mulch should be raked on top of the rows, and when a good breeze is blowing in the direction the rows run, a fire should be started on the windward side. When burning is done in this way, the fire will pass quickly, and the roots and crowns of the plants are not likely to be injured. The mowing and burning should be done immediately after the crop is harvested.

When renewing a plantation it is often desirable to reduce the number of plants in the matted row so that the plants will have a better chance to develop. The amount of thinning necessary will depend upon the variety and to some extent upon the season and the soil. Usually the plants should be thinned to 8 to 10 inches apart. They may be thinned by running a spike-tooth harrow or cultivator across the rows once or twice and then once down the row. The weaker plants are torn up by this process. A hoe may be used in further thinning the plants if they are still too thick. Within 2 or 3 weeks, under favorable conditions, the plants will have sent out new foliage and the field will have the appearance of a young plantation.

In some districts the rows are moved by plowing up one side of each row one year and having the remaining plants set runners in the alleys. The other half of the old row is plowed up the following year when the plantation is renewed, so that by the third year the rows run where the alleys were at first.

HARVESTING AND SHIPPING [5]

PICKERS AND PICKING

After berries of the best grade are grown they must be handled with great care if they are to reach the market in the best condition. The field should be picked over at least every other day, and at the height of the season it may be necessary to pick daily. No ripe berries should be left, since at the next picking they will be too soft to ship. One soft berry in a basket may spoil the entire contents and one spoiled basket of berries may spoil the looks of the crate by the time it reaches the market. The habit of growth of the foliage and the differences in growth of different varieties make it more difficult to pick clean in some sections than in others. The way in which dense foliage may hide the berries is shown in figure 23, *B*, and *C*, in contrast to the more open habit of growth shown in figure 23, *A*. In picking, the stem should be pinched off, leaving about half an inch attached to the berry. Each berry should be placed carefully (not thrown or dropped) in the basket. Baskets of berries should never be left in the sun, but should be taken to the packing shed or placed in the shade as soon as possible after the fruit is picked.

Pickers are paid by the quart for gathering the berries. The wage differs with the section, with the grade of work done, and with the plan of management. Thus, in one district pickers were paid by the gallon, and if they stayed until the end of the season, they were given an extra cent or two for each gallon picked during the season. This system serves to hold the pickers through the latter part of the season, when the berries are smaller and less plentiful. In another section

[5] See also Farmers' Bulletin 1560, Preparing Strawberries for Market. Can be purchased for 5 cents from Superintendent of Documents, Government Printing Office, Washington 25, D. C.

with the plan of management. Thus, in one district pickers are paid 6 cents a gallon, and if they stay until the end of the season, they are given another cent or two for each gallon picked during the season. This system serves to hold the pickers through the latter part of the season, when the berries are smaller and less plentiful. In another section some growers pay the best pickers one-half cent a quart more than they pay untrained and poor pickers. They consider that the extra pay encourages careful work and that the berries are worth more when handled by the best pickers.

FIGURE 23.—*A*, Strawberry plants that were set in September, showing the open habit of growth as compared with those shown in *B* and *C*. These berries are much easier to pick than those that are concealed, as in *B*. (Photographed at Chadbourn, N. C., May 3.) *B*, A Klondike strawberry plant, showing the heavy foliage which hides the berries. This makes picking difficult. *C*, The same strawberry plant shown in *B*, but with some leaves removed, showing the berries.

The number of pickers to the acre varies greatly. Where the yields are small two are sufficient. On the other hand, 8 or 10 are sometimes needed in the height of the season on the best fields. On a field yielding 100 crates (24-quart) to the acre, four pickers working every day should take care of the crop.

In a field that is given good attention there should be very few berries that are not of the best market grade. From some fields almost perfect berries have been secured, and no sorting after picking has been necessary. To obtain crops of such fruit, however, the plants

FIGURE 24.—*A*, A pony refrigerator which is used to ship strawberries from Florida to northern markets. Three sizes are used, 32-, 64-, and 80-quart. The ice pan, which fits in the top, is shown at the right. The tight-fitting cover is at the left. *B*, The strawberry shipping crates shown hold 24 quart baskets each. They are cheaply constructed and sometimes are called gift crates, because they are not usually returned to the shippers. The covers are nailed on. Two types of carriers used by pickers are shown in front.

should be properly spaced in the row, the field must be free from weeds and grass, and the mulch and the humus in the soil must be sufficient to maintain an adequate supply of moisture while the berries are growing and ripening.

CARRIERS AND CRATES

Carriers holding six 1-quart baskets are used in picking in most districts in the South Atlantic and Gulf States. Two types of carriers in common use are shown in figure 24, *B*. The carrier shown in figure 25, *A*, is cheaply constructed and very convenient. Field carriers are shown in figure 25, *B*.

The crate shown in figure 24, *B*, or one similar to it, is in common use in North Carolina, Alabama, Mississippi, and Texas. It holds twenty-four 1-quart baskets and is not usually returned to the grower when emptied. A somewhat similar type of crate holding either 24 pints or 24 quarts is used in Louisiana, and to a slight extent in Texas. The pony refrigerator shown in figure 24, *A*, is used largely in the central-Florida district. It is made in three sizes, holds 32, 64, or 80 quarts of berries, and has, either at the top or in the center, a metal tray filled with ice. A plan for a good type of packing house, typical of those much used in the South, is shown in figure 26.

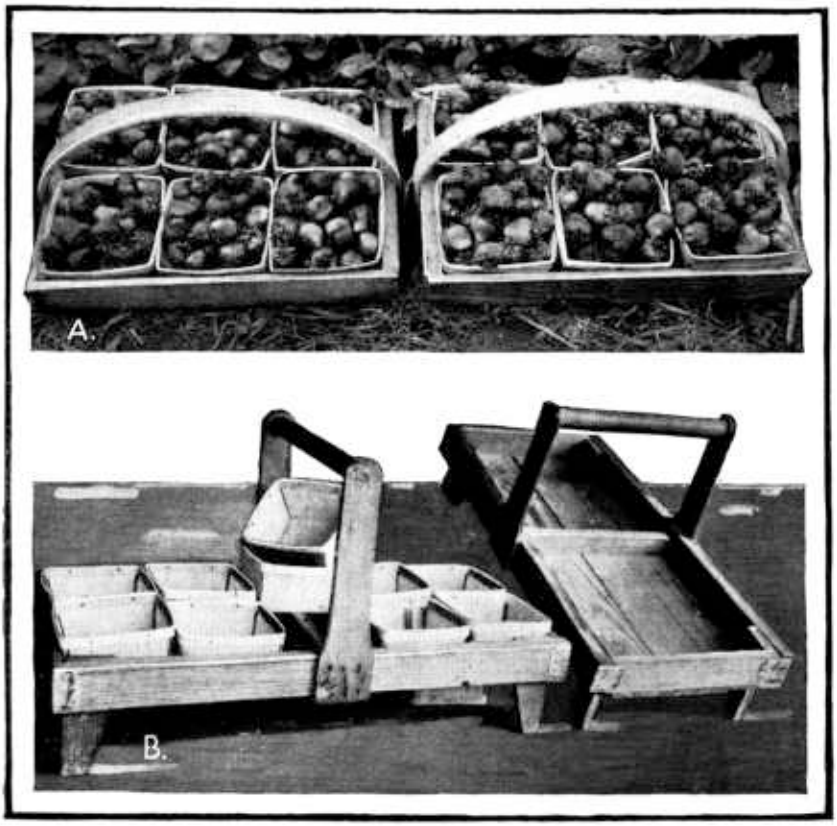

FIGURE 25.—*A*, Two 6-quart carriers, commonly used in picking berries. *B*, Two 10-quart carriers used to carry strawberries from the field to the packing house.

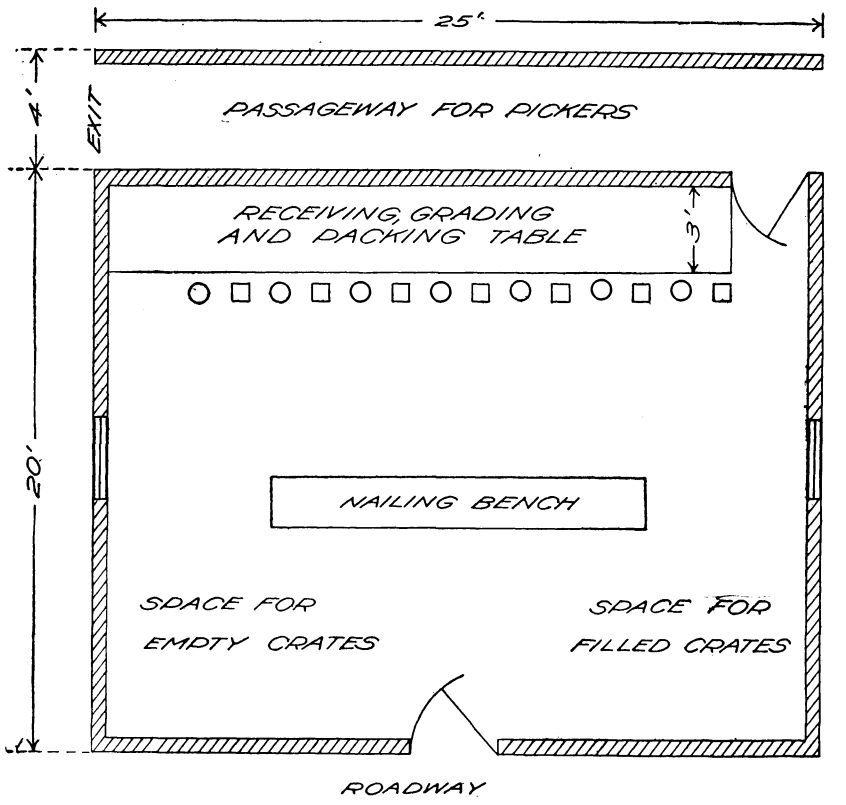

FIGURE 26.—A simple yet satisfactory plan for a strawberry packing shed.

SUITABLE STRAWBERRY VARIETIES

Only five varieties of strawberries, the Klondike, Klonmore, Blakemore, Massey, and Missionary, are grown extensively in the area to which this bulletin applies.

The Missionary grows better than the other varieties in the shortest days of the winter and with higher temperatures. The Klonmore is next to the Missionary and the Klondike is next to the Klonmore, but the Blakemore and Massey need more cold in order to start vigorous growth. Therefore, the Missionary is the best variety in Florida, the Klonmore in the belt just north, within 100 miles of the Gulf Coast, and the Blakemore just north of the Klonmore belt. The Missionary is almost the only variety grown in Florida, the Klonmore is the leading variety within a hundred miles of the Gulf Coast, and the Blakemore is the main variety northward. All except Klonmore are raised in eastern North Carolina, with the Massey leading. Near Norfolk, Va., the Blakemore is the only variety grown.

A new variety, Suwannee, was introduced in 1945, for testing as a home-garden variety in the Blakemore sections. The plant is vigorous, very productive, and drought- and disease-resistant; the berries are attractive and higher flavored than those of any other southern variety. They are too soft to be grown as a shipping variety.

Figure 27 shows where each variety is grown.

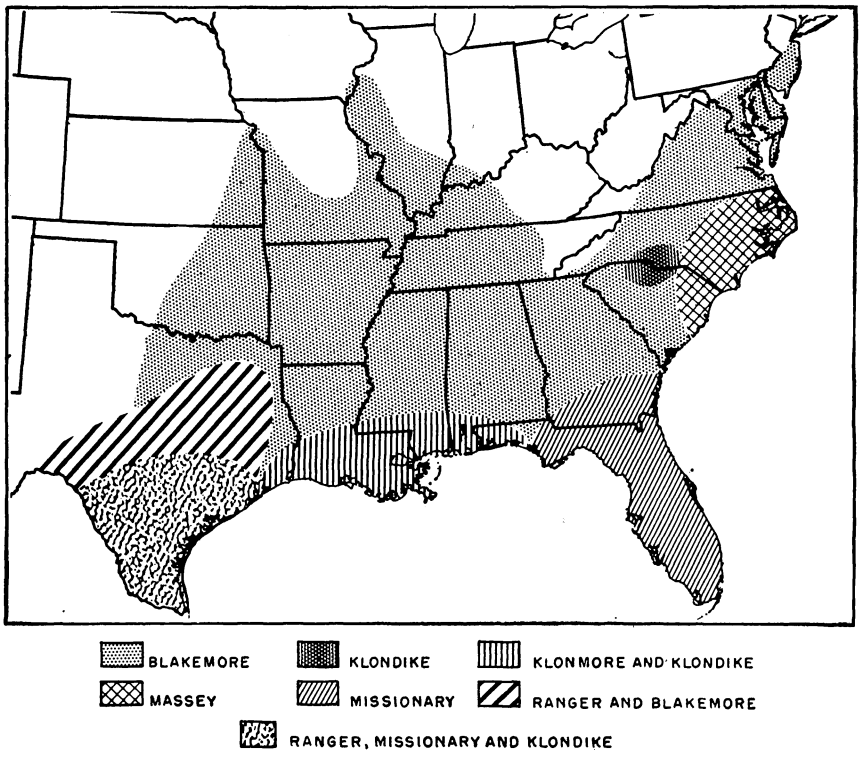

FIGURE 27.—Where southern strawberry varieties are grown.

STRAWBERRY DISEASES AND INSECT PESTS

No detailed discussion of strawberry diseases and insect enemies can be given in this bulletin. The grower should familiarize himself, so far as possible, with those that are likely to occur in his locality, and thus be able to recognize and combat them as soon as they are discovered. Information on pests and diseases may be found in many bulletins of the State agricultural experiment stations and State agricultural colleges, and in publications of the United States Department of Agriculture.[6] Growers should keep in close touch with the experiment stations in their own States and upon discovering unfamiliar insects or diseases should send specimens to the stations or to the U. S. Department of Agriculture for examination. Early recognition of an insect or a disease newly discovered in a community may make it possible to apply control measures that will prevent a serious outbreak.

USES OF THE STRAWBERRY

Many million dollars' worth of strawberry products are manufactured each year. Among the more important of these are preserves, jams, essences for flavoring candies, flavoring extracts, syrup for soda fountains, and crushed fruit for flavoring ice cream and sauces. All important southern varieties are superior to most strawberries

[6] U. S. Dept. Agr. Farmers' Bulletin No. 1891, Diseases of Strawberries.

for some of these purposes. The varieties considered best for preserving are light, bright red, acid, with a strong strawberry flavor, and firm fleshed, so that they will not break to pieces in cooking. For the ice-cream trade, varieties with a deep red color and high flavor are desired. The best variety for preserving is the Blakemore.

The Klondike is one of the best of all varieties for flavoring ice cream and for freezing for the small-package trade. Both the Missionary and the Blakemore are also very good for these uses. Southern berries are rarely canned. The recent extension of the cold-storage locker movement is causing the replacement of canning and even of preserving for home use by the freezing of strawberries, as well as other fruits, in small containers. A heavy sirup is poured over the berries, after which they are placed in the cold storage as soon as possible.

COLD STORAGE

Preservers and large manufacturers of the crushed fruits and sirups used by the soda-fountain and ice-cream trade prepare their product as it is needed at any time during the year from uncooked berries kept in barrels and smaller containers in cold storage and preserved in the following manner: The berries are hulled and sorted and then washed. Various kinds of washing machines are employed. Usually the machine has a water tank at one end into which the berries are dumped for a brief soaking to loosen the dirt. From this tank they are removed by an endless belt which carries them under sprays of fresh water. This belt delivers them to inspection belts where the water drains away and the final sorting and grading are done. The berries are then put in containers with the desired quantity of sugar. Usually the proportion is 1 pound of sugar to 3 pounds of fruit, though 1-to-4 and 1-to-5 packs are also made, as these are preferable for some purposes. Heavy water-tight barrels holding about 450 pounds of the mixture of berries and sugar are used. Before being used they are carefully examined and coated on the inside with paraffin applied, while hot, with a paint brush. New barrels made of some kinds of wood may need special treatment to prevent the berries from absorbing a woody taste.

The sugar and berries are put in the barrels in alternate layers and mixed by machine or by hand. A jolting platform which jars the barrel as it is being filled with berries and sugar has come into common use. As soon as the barrels are headed, they are shipped to a cold-storage warehouse, where they are stored for at least a week at 0° F. and then held at about 15°. From 75,000 to 125,000 barrels of strawberries, each holding 50 gallons, or the equivalent in smaller containers, are put up in this manner every year.

For dessert use, berries are packed in small cartons, usually containing about 1 pound of berries, either entire or sliced, and with or without the addition of sugar or sirup. The berries are washed and prepared as for packing in barrels but are placed in the smaller packages for retail use. A recent development consists in freezing the berries by immersing or spraying them with a sirup which freezes them very quickly.

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